Anatomy of flowering Plants

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★ Study of internal str. of plants → Anatomy

- Plants → cells → basic unit → org. into → tissue → org. into → organs
- Within angiosperm → monocot & dicot → anatomically different

different organs in plant shows difference in internal structure

★ Internal structures show adaptation to → Diverse Environment ★

Imp

THE TISSUES → Grp of cells having → common origin / usually performs → common function

Plant is made up of different kinds of tissues mainly 2 on basis of whether cells being formed are capable of dividing or not

Meristematic | Permanent

MERISTEMATIC TISSUES

Growth in plants → Largely restricted to → Specialised region of active cell division → called meristems

Plants have diff. kinds of meristems

Primary meristems → occur early in life of a plant & contribute to form. of plant body

Apical Meristems

Meristems which occur at tips of roots & shoots and ↓ produce primary tissues

RAM occupies → tip of root

SAM occupies → distant most region of stem axis

During the ① form. of leaves & ② Elongation of stems

Intercalary meristems

Meristems which occur in mature tissues

- Occur in → Grasses → regenerate parts removed by grazing herbivore

Secondary/Lateral Meristem

Occur in mature region of → roots / shoots

particularly those which produce woody axis & appear later than primary meristem.

- These are cylindrical meristem.
- Responsible for producing → sec. tissue

Eg. Fascicular V. cambium, Interfascicular " " , Cork cambium

Some cells left behind form SAM

constitute

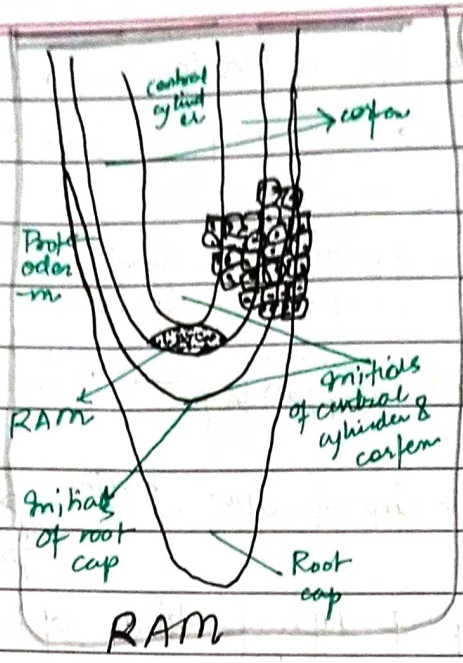
Axillary bud

present in

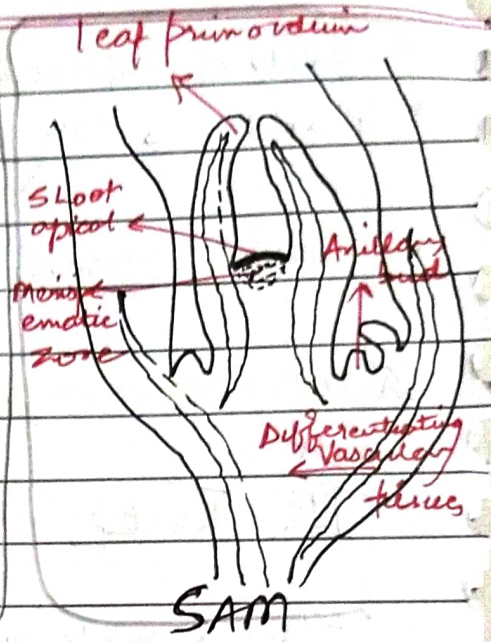
axils of leaves

capable of forming

branch flower.



RAM



SAM

* Following divisions of cells in both → primary, → secondary meristem → newly formed cells become → structurally, functionally → specialised

→ such cells → lose ability to divide

Permanent / mature cells

consist → permanent tissues

- During the form of primary plant body

Specific regions of apical meristem

produce

Dermal tissues | Ground tissues | Vascular tissues

PERMANENT TISSUES

Simple tissues
All cells similar in structure & function

Complex Tissues
having many diff. types of cells which do not divide further.

Parenchyma

- Forms major component within organs of plant.
- Cells of parenchyma
  - Isodiametric
  - May be
    - spherical
    - oval
    - round
    - polygonal
    - elongated
  - on shape
- Cell walls → thin → cellulosic
- Either
  - Closely packed
  - OR → have small intercellular spaces
- Functions → Secretion
  - Photosynthesis
  - Storage

Collenchyma

Occurs in → Layers below epidermis in most dicot plants.

Found as
- Homogenous layer
- OR
- Patches

Cells → Much thickened at corners due to deposition of
- cellulose
- hemicellulose
- pectin

Cells of this tissue may be
- oval
- spherical
- polygonal

often contain chloroplast → these cells assimilate → contains chloroplast when

- Provide → mechanical support to the growing parts of plant eg
  - Young stem
  - Petiole of leaf

Sclerenchyma

provides mechanical support to organs

Consists of
- Long
- narrow
- thick lignified walls
- Few or numerous pits

- Usually dead → without protoplast
- On basis of origin, form, structure, development

Sclerenchyma may be either

Fibres
- Thick
- Elongated
- Pointed cells
- Generally in groups in various parts of plant

Sclereids
- spherical
- oval
- cylindrical
- highly thick dead cells → with narrow cavities lumen

- Found in
  - Fruit wall of nuts
  - Pulp of fruits like guava, pear, sapota
  - Seed coat of legumes
  - Leaves of tea

Complex tissues

made up of more than one type of cells
work together as a unit
constitute → Xylem
→ Phloem.

XYLEM

conducting tissue for transporting water from soil to minerals

Provides – Mechanical strength to plant parts

Xylem (Gymnosp. lack this)

Tracheids	Vessels	Xylem fibres	Xylem Parenchyma
• Elongated • Tube like • Tapering ends • Thick, lignified walls • Dead without protoplasm • Inner layers of cell walls have thickening which vary in form.	• Long • Cylindrical • Tube like • made up of many cells Vessel members each has • lignified walls • Large central cavity Dead • Vessel cells devoid of protoplasm • Vessel members interconnected through Perforation in their common walls.	• Highly thickened walls • Obliterated central lumens • Either be SEPTATE / ASEPTATE Dead	• Living • Thin walled • Cell walls of cellulose • Store food in form of starch / fat / other subst. like tanning The radial conduction of water take place by Ray parenchy cells

*Presence of vessel → character of → Angiosperm

• Tracheids / Vessels → main water transporting element in flowering plants.

Primary Xylem — two types

Protoxylem
- 1st formed primary xylem
- Two types of arrangement → Endarch
  - Proto – pith
  - Meta – periphery
  - Eg. stems

Metaxylem
- Later formed primary xylem
- → Exarch
  - opposite
  - Eg. Roots

PHLOEM

transports food material from leaves to other parts of plant
→ in gymnosperm.
→ in angiosperm composed of

Sieve tube Elements	Companion cells	Phloem Parenchyma	Phloem fibres
• Long • Tube like arranged longitudinally • associated with • Their end walls perforated in Sieve like manner to form Sieve plates • A mature Sieve element has Lack nucleus, Peripheral cytoplasm, Large vacuole	(Specialised parenchym. cells) • closely associated with sieve tube elements • Connected to sieve tube elements by pit fields present b/w their common longitudinal walls. • Functions help in maintaining pressure gradient in sieve tube	made of ↓ • Elongated • tapering • Cylindrical cells • Dense cytop. • Nucleus (cellulose) • Cell Wall has pits through which plasmo dermatal connection exists b/w the cells. • Stores → food, resin, tanin, mucilage *Phloem parenchyma absent in monocots	Bast fibres made up of Sclerenchyma dead cells • Absent in primary phloem • Found in sec. phloem • Elongated • Unbranched • Pointed • needle like apices Cell wall → thick At maturity these fibres lose protoplasm → become dead. • Phloem fibres of Flax, jute, hemp used commercially

Functions of sieve tubes are controlled by nucleus of companion cells.

Protophloem
First formed primary phloem → consists → narrow sieve tubes

Metaphloem
Later formed primary phloem → consists → bigger sieve tubes

THE TISSUE SYSTEM. → Based on types of cells present

parenchy. collenchyma Schlerenchyma.

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Based on location in the plant body

* Their → structure → function would also be dependant on location.

Epidermal Tissue system	Ground tissue (Fundamental) system	Vascular (Conducting) tissue system

* On Basis of → structure, Location → 3 types of tissue system.

Epidermal Tissue System.

Forms : outermost covering of whole plant body

Composes → Stomata, Epidermal cells, Epidermal appendages → trichomes, hairs

* EPIDERMIS : Outermost layer of primary plant body

made up of → Elongated, compactly arranged → cells → which forms continuous layer.

usually → single-layered.

* Epidermal Cells → • Parenchymatous
  • Small amt of cytoplasm lining cell wall
  • Large vacuole.

* Outside of Epidermis covered by → Cuticle
  • Waxy
  • Thick layer

* Cuticle absent in roots.

* Epidermis of leaves has → STOMATA
  regulate the process of → Transpiration, Gaseous exchange

* Stomata composed of → 2 bean shaped cells known as → Guard cells.
  ↓ enclosed
  Stomatal pore.

* In Grasses Guard cells → Dumbell shaped.

Outer wall of stomata → away from stomatal pore → thin

Inner wall of stomata → towards stomatal pore → Highly thickened

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★ Gaurd cells → possess chloroplast
└ regulate → • opening • closing → of the stomata.

★ Few epidermal cells → in vicinity of gaurd cells → become specialised in shape and size → known as Subsidiary cells

Stomatal Aperture + Gaurd cell + Surrounding subsidiary cell.
↓
Stomatal apparatus.

Cells of Epidermis bear → number of hairs

Root hairs

⊙ Unicellular elongations of epidermal cells

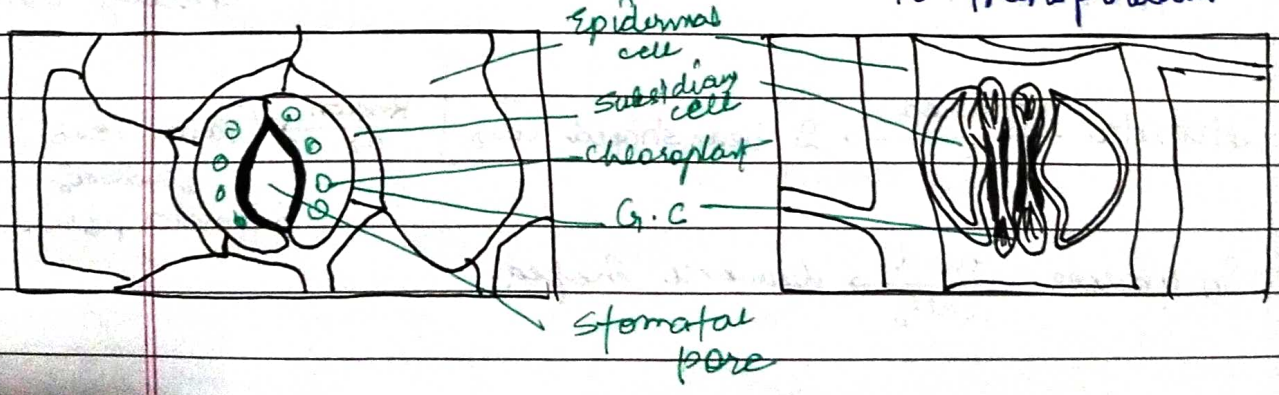
⊙ Help absorb → water, minerals → from soil

Trichomes → secretory

⊙ On stems, these epidermal hairs present.

In shoot system → trichome → Multicellular → maybe Branched OR Unbranched and Soft OR Stiff

⊙ Prevents water loss due to transpiration



GROUND TISSUE SYSTEM.

→ main bulk of plant

All tissue except epidermis, Vascular bundles

consists of lot of simple tissues

divided into 3 tissues: Cortex, Pericycle, Pith

Parenchyma, Collenchyma, Sclerenchyma

Parenchyma cells present in:
- Cortex
- Pericycle
- Pith
- Medullary rays
- In primary → stem, root

In Leaves — Ground tissue consists of
- thin walled
- Chloroplast containing cells

called mesophyll.

VASCULAR TISSUE SYSTEM

consists of Complex tissue

Xylem + Phloem together constitute → Vascular Bundle.

DICOT STEM →

Xylem || Phloem

cambium

① Sec. Xylem

② Sec. Phloem

Hence, such vascular bundles possess the ability to form

OPEN VASCULAR BUNDLE ← hence called

MONOCOTYLEDONS → V.B ✗ no cambium

↓ do not form Secondary tissues

CLOSED V.B ← Hence called

★ On basis of → presence of cambium
→ location of → Xylem, Phloem

V.B are of different types

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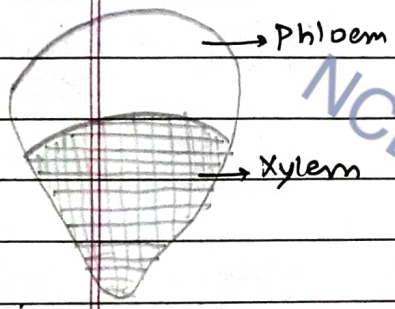
CONJOINT

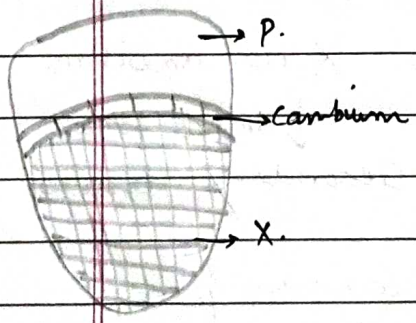
- Xylem Phloem
  ↓
  Jointly situated
  along the same radius of V.B

- Eg in → Stems, Leaves

* Usually have
  ↓
  phloem on outer side



* Conjoint closed



* Conjoint open.

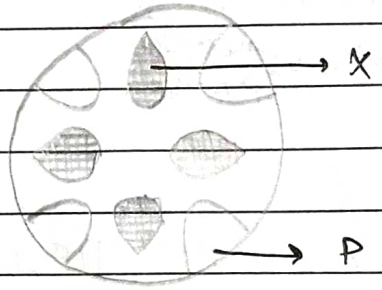
RADIAL

↓

Xylem Phloem
↓
within V.B

arranged in alternate manner along the
↓
different radii

Eg in → Roots



DICOT ROOT

Transverse section of SUNFLOWER ROOT

Outermost layer : Epiblema

Unicellular Root hairs ← many cells of epiblem protude in form of

CORTEX consists of Several layers of

-) thin walled
-) Parenchymat. cells
-) ~~Intercellular spaces~~

its innermost layer → ENDODERMIS

comprises

- Single layer of Barrel shaped cells
- without any intercellular spaces

Endodermal cells

Tangential wall — Radial wall

have deposition of

Suberin in form of CASPARIAN STRIPS

water impermeable ↖ ↙ wavy

Next to endodermis → PERICYCLE

consists of

- Few layers of
  - ① Parenchymatous cells
  - ② thick walled

- Initiation of
  - ① Vascular cambium
  - ② lateral roots

during secondary growth takes place in pericycle

MONOCOT ROOT

Anatomy of monocot root similar to Dicot Root. (in many respects)

Has →
-) Epidermis
-) Cortex
-) Endodermis
-) Pericycle
-) Vascular Bundles
-) Pith

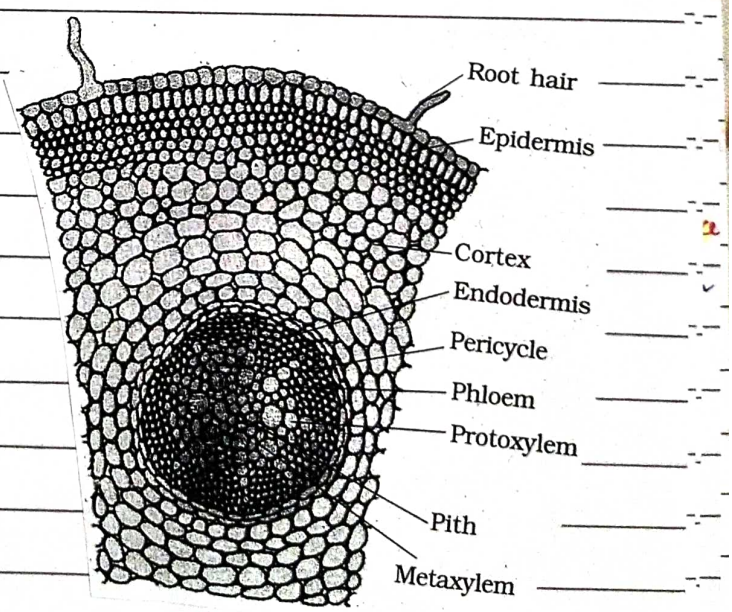
Xylem bundles → usually more than 6.

POLYARCH

PITH → Large

Well developed

★ Monocot Root → ✗ Sec. growth



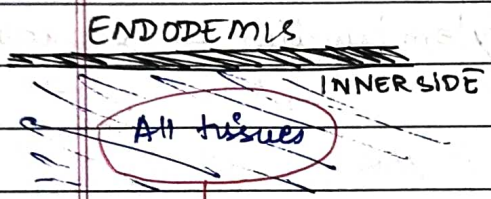
Transverse sect.

PITH → • Small
• Inconspicuous

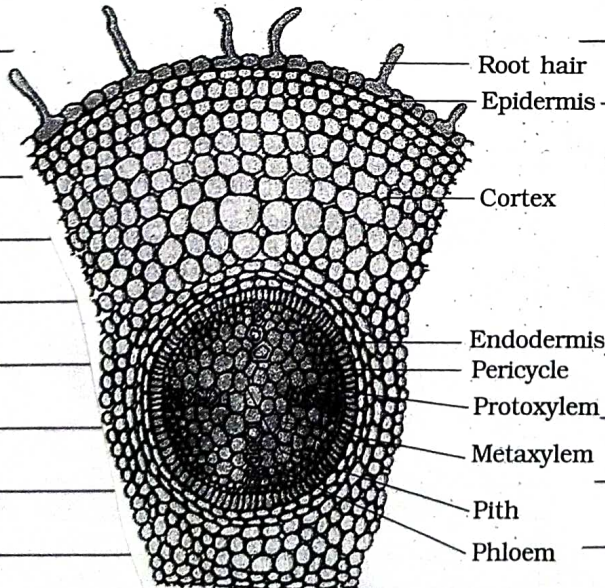
Xylem -- PARENCHYM. CELLS -- Phloem
in b/w
↓called
Conjuctive tissue

usually / no. present
2 – 4

Later, Cambium Ring develops b/w xylem & phloem



↓
constitute stele
↓
- Pericycle
- Vascular Bundles
- Pith



Transverse sec.

DICOT STEM

TRANSVERSE SECTION of Young Dicot stem. ↓ shows

- **Epidermis**
  - Outermost ⊙ Protective layer
  - Covered with → thin layer of cuticle.
  - may bear → Trichomes; few stomata.
- Cells arranged in → multiple layers b/w epidermis & pericycle
- constitute → **Cortex**
- consists of 3 sub-zones

Outer	Middle	Inner
Hypodermis	**Cortical layers**	**Endodermis**
Few layers of collenchymatous cells just below epidermis → provide Mechanical strength to young stem.	• Below the hypodermis • Consists of → • Round • Thin walled • Parenchymatous cells • Has conspicuous intercellular spaces.	• Cells rich in starch grains → hence is this layer referred Starch sheath On INNER SIDE OF ENDODERMIS → present → **Pericycle** • Above phloem • Form of semi-lunar patches of sclerenchyma

IN B/W VASCULAR BUNDLES there are
- Few layers of
- Radially placed

→ PARENCHYMATOUS CELLS constitute → medullary rays

MONOCOT STEM

Hypodermis — Sclerenchymatous

Large no. of Scattered **Vascular Bundles** each surrounded by Sclerenchymatous bundle sheath

- Large
- Conspicuous
- Parenchymatous

→ Ground tissue

Vascular Bundle
-) Conjoint
-) Closed

Peripheral Vascular Bundle → Smaller generally than centrally located ones

★ Phloem parenchyma → absent

★ Water containing cavities present within Vascular Bundle.

LARGE NO OF → VASCULAR BUNDLES

A ring ← arranged in

This ring arrangement → Characteristic of dicot stem.

EACH Vascular Bundle

↓

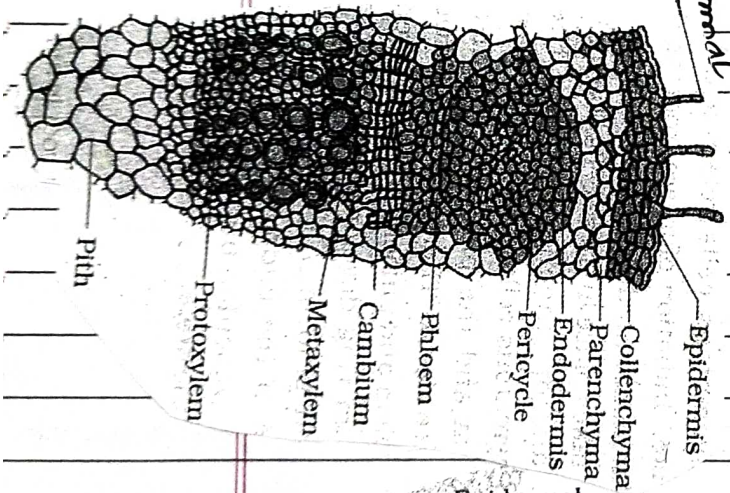
1) Conjoint
2) Open
3) Endarch protoxylem

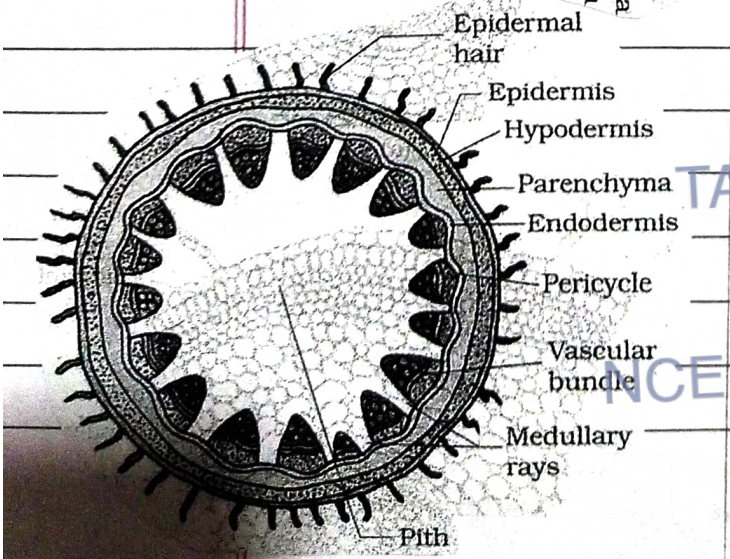
PITH → Large no. of
- Rounded
- Parenchymatous cells
- Large intercellular spaces cells

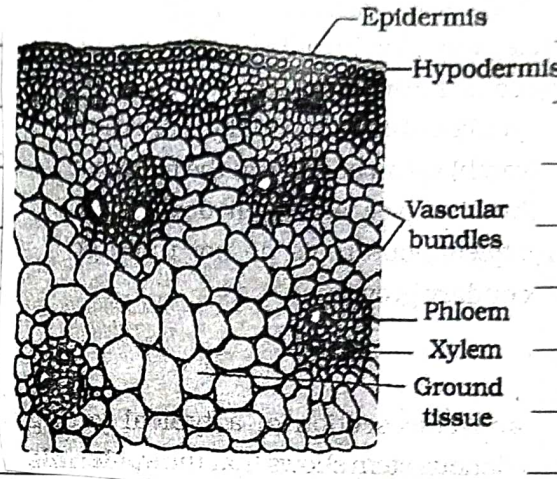
constitute → Central portion of stem

occupy

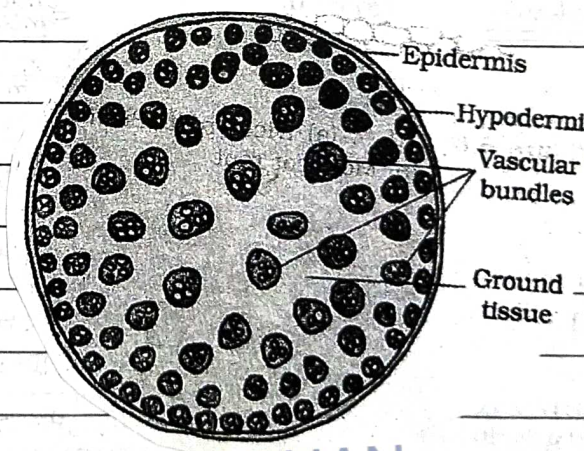
Transverse sect.







Transverse sect.



DICOT LEAF
(Dorsiventral leaf)

- Vertical Section through the Lamina shows 3 main parts

→ Epidermis (has conspicuous cuticle)
- Adaxial Surface → Upper
  - Less stomata (may even lack stomata)
- Abaxial surface → Lower
  - More stomata

→ Mesophyll — Tissue b/w upper & lower epidermis
- Posses chloroplyll.
- Carry out photosynthesis.
- Made of Parenchyma

2 types of cells:

Palisade Parenchyma	Spongy parenchyma
• Adaxially placed	• Oval
• Elongated cells	• Round
• Arranged, vertically & Parrallel to each other.	• Loosely arranged
• Compact	• Situated → below palside cells → extend to lower epidermis
	• Has numerous large space & air cavities

→ Vascular system
- Has vascular bundles → seen in Veins & midrib

★ Size of vascular bundles ↓ depend on size of veins

MONOCOT LEAF
(Isobilateral leaf)

Anatomy of monocot leaf & dicot leaf similar in many ways

Characteristic differences →

★ Stomata - present on both surface

★ Mesophyll — not differentiated into palisade & spongy

In GRASS,

Certain adaxial Epidermal cells ↓ along the veins ↓ modify themselves into

large colourless empty cells

↓

Bulliform cells ↓ these when absorb Water ↓ becomes turgid. ↓ then

Leaf surface - exposed.

when flaccid ↓ due to water stress

leaves curl inwards ↓ tend to minimize water loss

Veins vary in thickness in Reticulate venation

Parallel venation in monocot leaves

reflect

Vascular Bundles surrounded by BSC

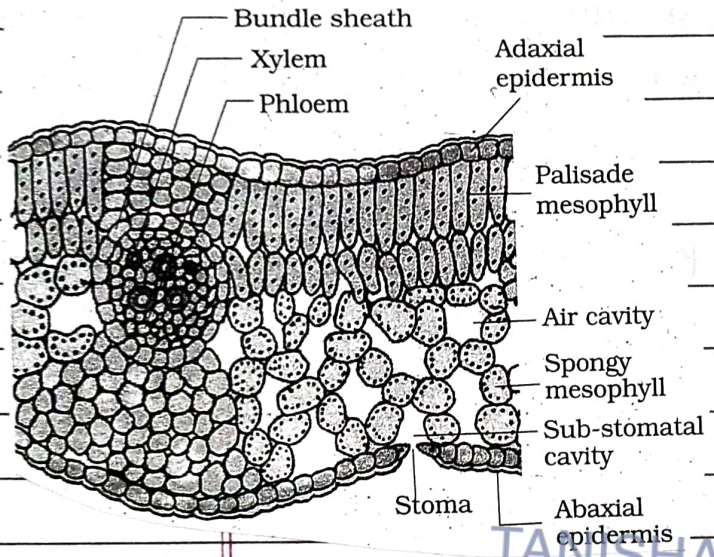
↓

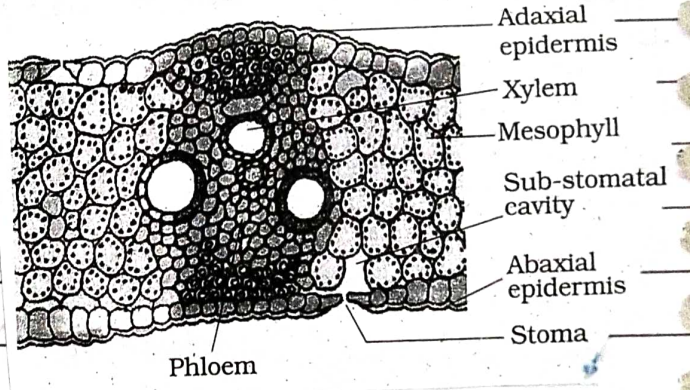
Bundle sheath cells

Similar size of vascular bundles (except in main veins)

↓

as seen in vertical sections of leaves.





SECONDARY GROWTH

Primary growth ↑ in length of → Roots, Stems — occurs with the help of → Apical Meristem

Most dicotyledons — exhibit → ↑ in girth — called Secondary growth — tissue involved → Cork cambium, Vascular cambium

2 lateral meristematic tissues

VASCULAR CAMBIUM

- meristematic layer
- responsible for cutting off vascular tissues → Xylem, Phloem.
- In young stems → present in patches as single layer b/w xylem & phloem.
- Later → forms complete ring

Formation of Cambial Ring

In dicot stems → "Cells of cambium" present b/w xylem & phloem (primary) — called → Intrafascicular Cambium

"Cells of medullary rays" adjoining these intrafascicular cambium become meristematic — form → Interfascicular Cambium

Thus → A continuous ring formed.

Activity Of Cambial Ring

becomes active & begins to cut off cells towards

Inner side

- Cells cut off towards pith → mature into Secondary xylem
- Cambium more active
- Amt produced is more → Soon forms a compact mass

Outer side

- Cells cut off towards periphery → mature into Secondary phloem
- Cambium less active
- Amt produced is less

★ Secondary phloem ★ prim p.-ary

Gets crushed due to continued form. of & accumulation of secondary xylem

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⊙ Primary Xylem → More of less ① Remain Intact. OR ② Around the centre.

★ At some places → Cambium forms → narrow band of Parenchyma

Secondary Medullary Rays ← forming [in radial direction ← Sec. xylem, Sec. phloem ← which passes through]

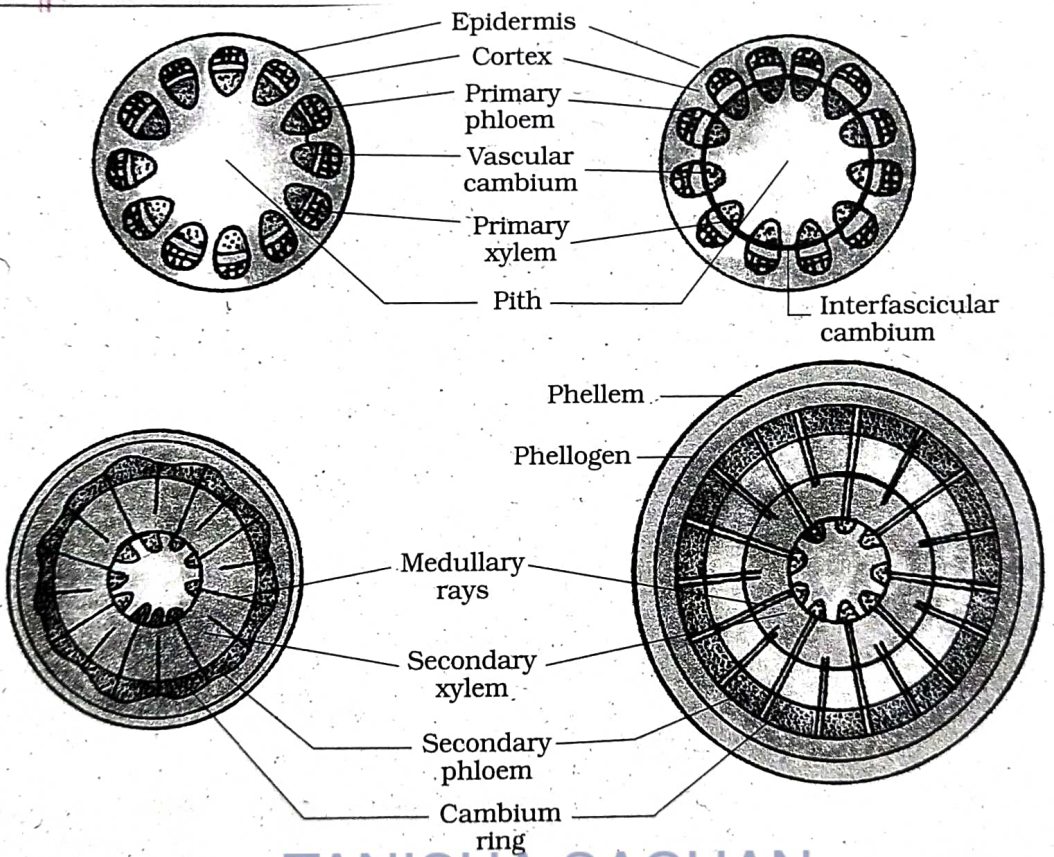

Figure 6.9 Secondary growth in a dicot stem (diagrammatic) – stages in transverse views

Wood —is actually→ Secondary Xylem

Different types of woods — on basis of → their composition, time of production

Spring Wood / Early Wood

- In ↓ spring season
- Cambium very active
  - ↓ produces
  - Large no. of Xylary elements ↓ with vessels with wider cavities
- Lighter in colour
- Low density

Autumn Wood / Late wood

- In ↓ winter (× not autumn)
- Cambium less active
  - ↓ produces
  - Fewer no. of Xylary elements ↓ with narrow vessels
- Darker in colour
- Higher density

Two kinds of woods that appear as alternate concentric rings
↓ constitute
Annual Rings
- ← Seen in cut stem (this gives)
- → estimate the age of trees.

Activity Of Cambium → under the control of ① physiological & ② environmental factors.

- In temperate region → climatic conditions → Not uniform through the year.
  - Hence, autumn & spring wood is formed.

Heartwood (duramen)

- In old trees
  - ↓ Greater part of Sec. Xylem
    - ↓ Dark brown in colour due to deposition of
      - ① tannins
      - ② resins
      - ③ oils
      - ④ gums
      - ⑤ from org. acids, alc. subs.
      - ⑥ essential oils
    - ↓ In central & innermost layers of stem.

Sapwood (albumum)

- Peripheral Region of Sec. Xylem
  - ↓ Lighter in colour
    - ↓ Involved in conduction of water & minerals from root to leaf.

- These substance make it
  - hard
  - durable
  - Resistant
    1. to attacks of micro-organisms
    2. insects

This region have dead elements with highly lignified walls.

- Does not conduct water but gives mechanical strength to stem.

CORK CAMBIUM

Stems continue to ↑ in girth due to activity of Vascular Cambium

Vascular Cambium → ① Outer cortical ② Epidermis layer

get broken → need to be replaced to provide new protective cell layers

hence sooner or later → Another meristematic tissue → Cork Cambium formed.
OR
PHELLOGEN

PHELLOGEN
- in Cortex region
- Couple of layers thick, made of
  1. narrow
  2. thin-walled
  3. nearly rectangular cells
- cuts off cells on both sides

Outer cells → differentiate into Cork OR PHELLEM → impervious due to Suberin deposition in the cell wall.

PHELLOGEN + PHELLEM + PHELLODERM → PERIDERM.

Inner cells → differentiate into Secondary cortex OR PHELLODERM → Cells: Parenchymatous

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★ Due to activity of the cork cambium → pressure builds up on remaining layers peripheral to phellogen. → ultimately → These layers die & slough off.

★ Bark → is a non-technical term

→ Refers to → All tissues exterior to Vascular Cambium therefore including Sec. Phloem

includes → Periderm, Sec. Phloem

Early / Soft bark — Formed early in season

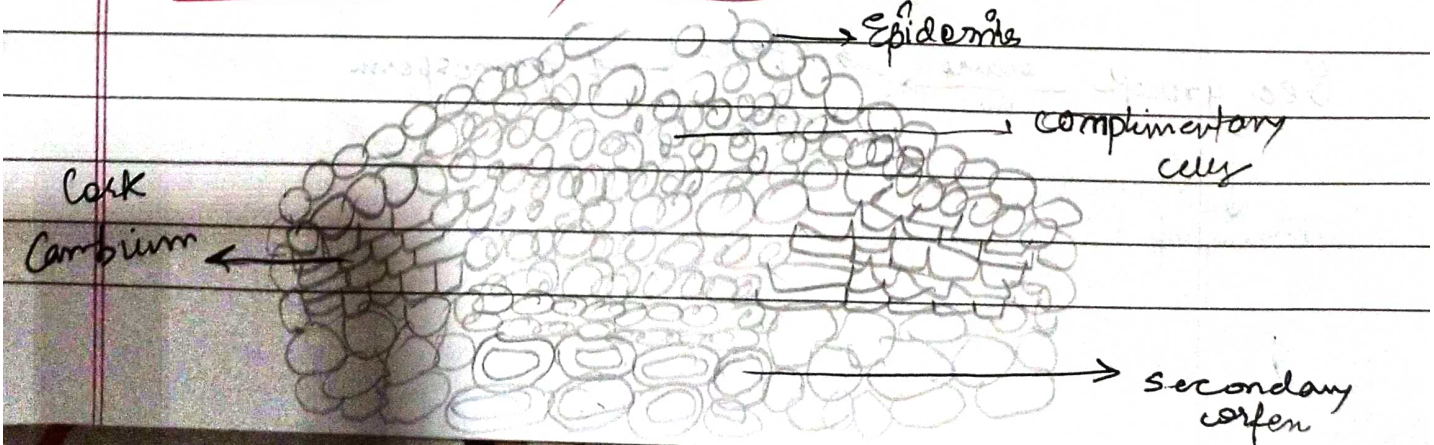
Late / Hard Bark — Formed late/end in season.

★ At certain regions → Phellogen cuts off loosely arranged parenchymatous cells on outer side instead of cork cells. These parenchyma cells → forming → Soon rupture the epidermis

Lens shaped openings → Lenticels.

Lenticels permit → gas exchange of gases b/w the outer atmosphere & internal tissues of stem

Occur mostly in woody trees.



Sec. Growth in Roots

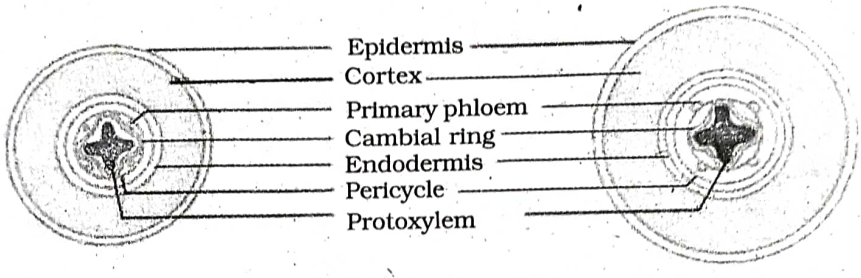
Vascular Cambium → Completely secondary in origin

originated from:
① Tissue located just below the phloem bundles
② a portion of pericycle tissue
③ above protoxylems

forming ← Complete & Continuous → Wavy ring

later which becomes → Circular

* Further events are similar to that of dicot stem.



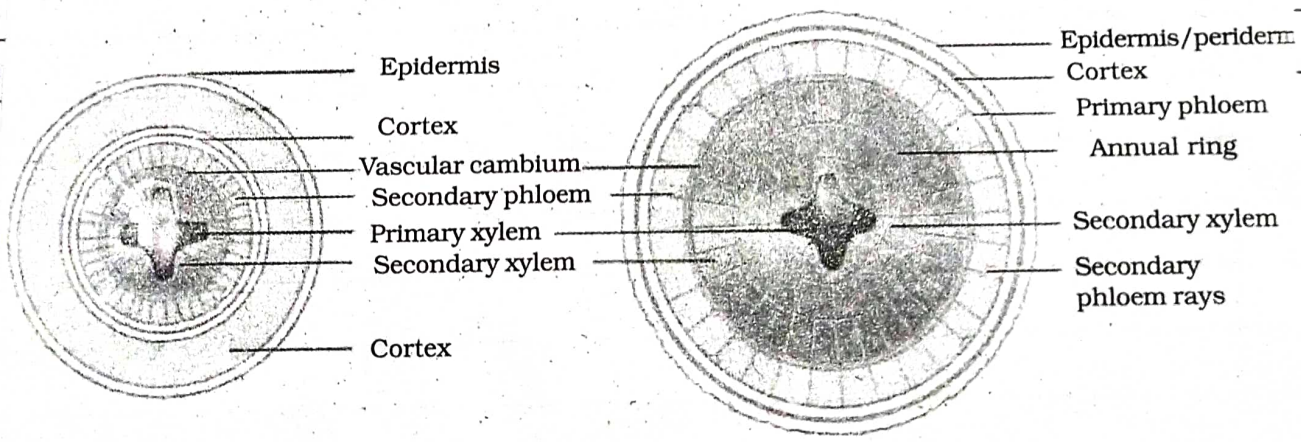


Figure 6.11 Different stages of the secondary growth in a typical dicot root

Sec. growth occurs in → stems, roots → of gymnosperm

↓ X

monocot